Conformable Array for Mapping Corrosion Profiles

DE-FC26-01NT41153

Presented by
Southwest Research Institute
(Cofunding by Clock Spring Co.)

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Project Justification

Significant corrosion and other defects detected and located by in-line inspection technologies must undergo further assessment to determine their severity. This assessment usually entails excavation and cleaning to expose the bare pipe and to make measurements of defect size and shape so that industry standards of acceptance can be applied. This project is to determine the feasibility of a new method for such measurements.

Feasibility Objectives

- Accuracy and range to meet needs of B31G and RSTRENG calculations
- Convenience of use that does not require extensive training or auxiliary hardware
- Cost low enough to justify units deployed at the district maintenance level
- Compatibility with pipeline field environment

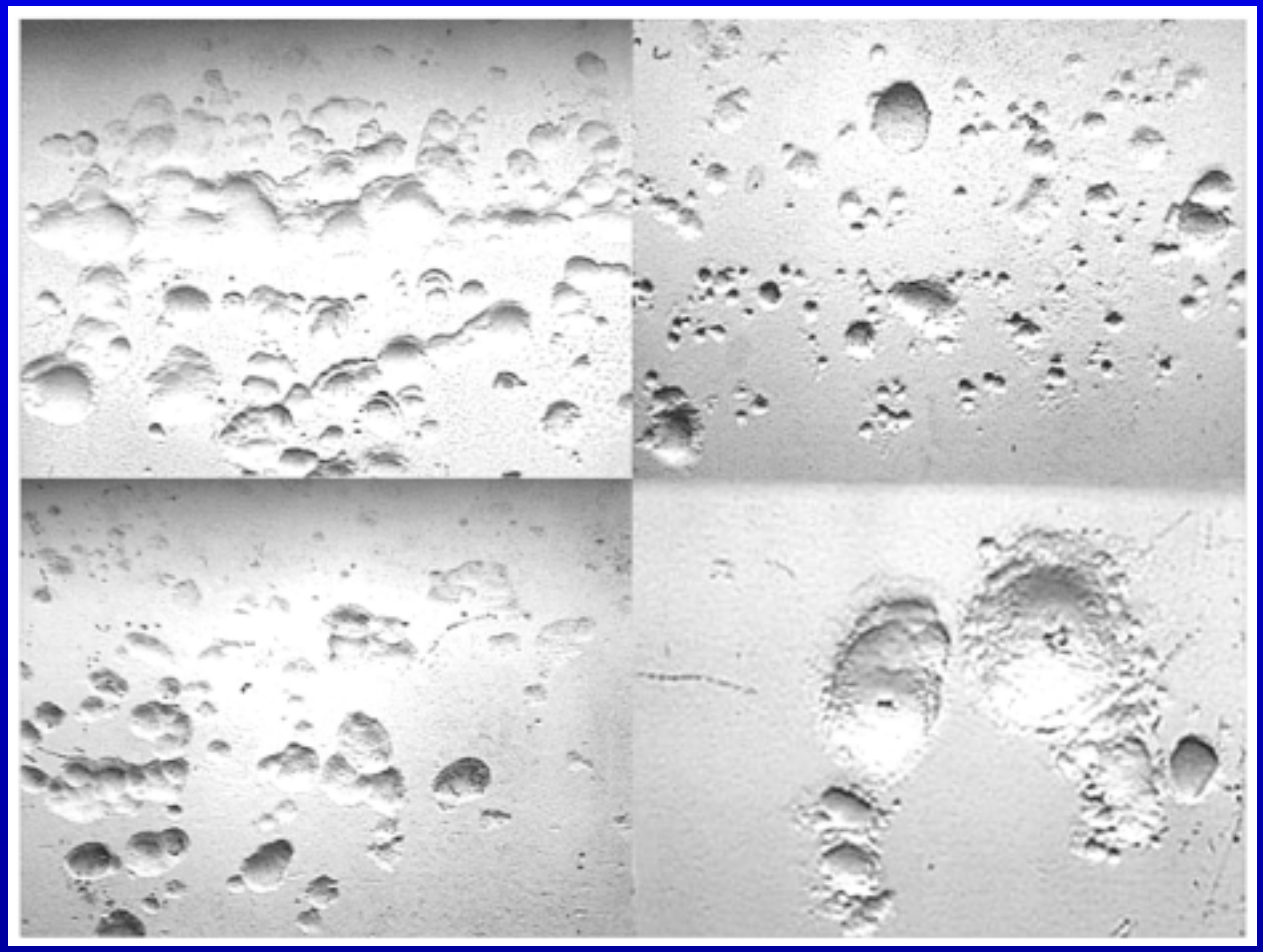
Project Tasks

- Determine the state of the art in eddy current stand-off measurement
- Optimize sensor design through simulations and laboratory experiments
- Design array drive circuitry
- Develop data display approach
- Transfer technology to Clock Spring Co.

Clock Spring Role in Project
(is contributing to the following tasks)

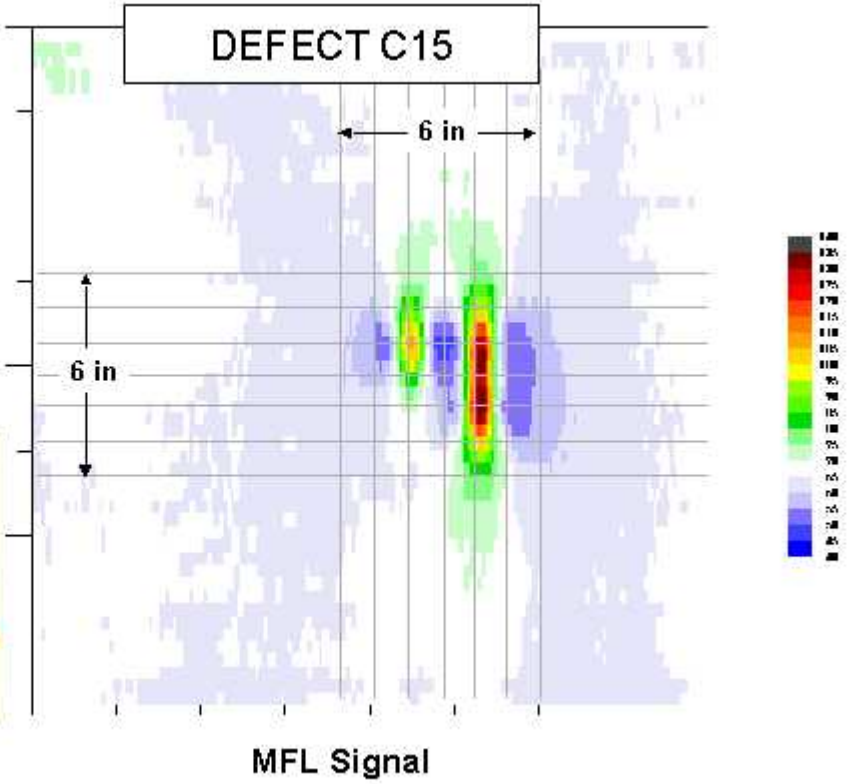
- Technology Status Assessment
- Determine sensor operating parameters
- Determine data acquisition requirements
- Determine display approach
- Specify software requirements
- Prepare final report

Four Pipeline Corrosion Coupons



MFL Color Map Data

- 50% Deep
- 1" Long
- 1" Wide
- Spaced 1" apart in the axial and hoop direction



Current Methods of Corrosion Assessment

- Toothpick, matchstick, twig, scale
- Depth gage without bridging bar
- Bridging bar and depth gage
- Grid with ultrasonic spot measurement
- Laser-ranging measurement system
- Automated ultrasonic scanner

Bridging Bar with Pit Depth Gage

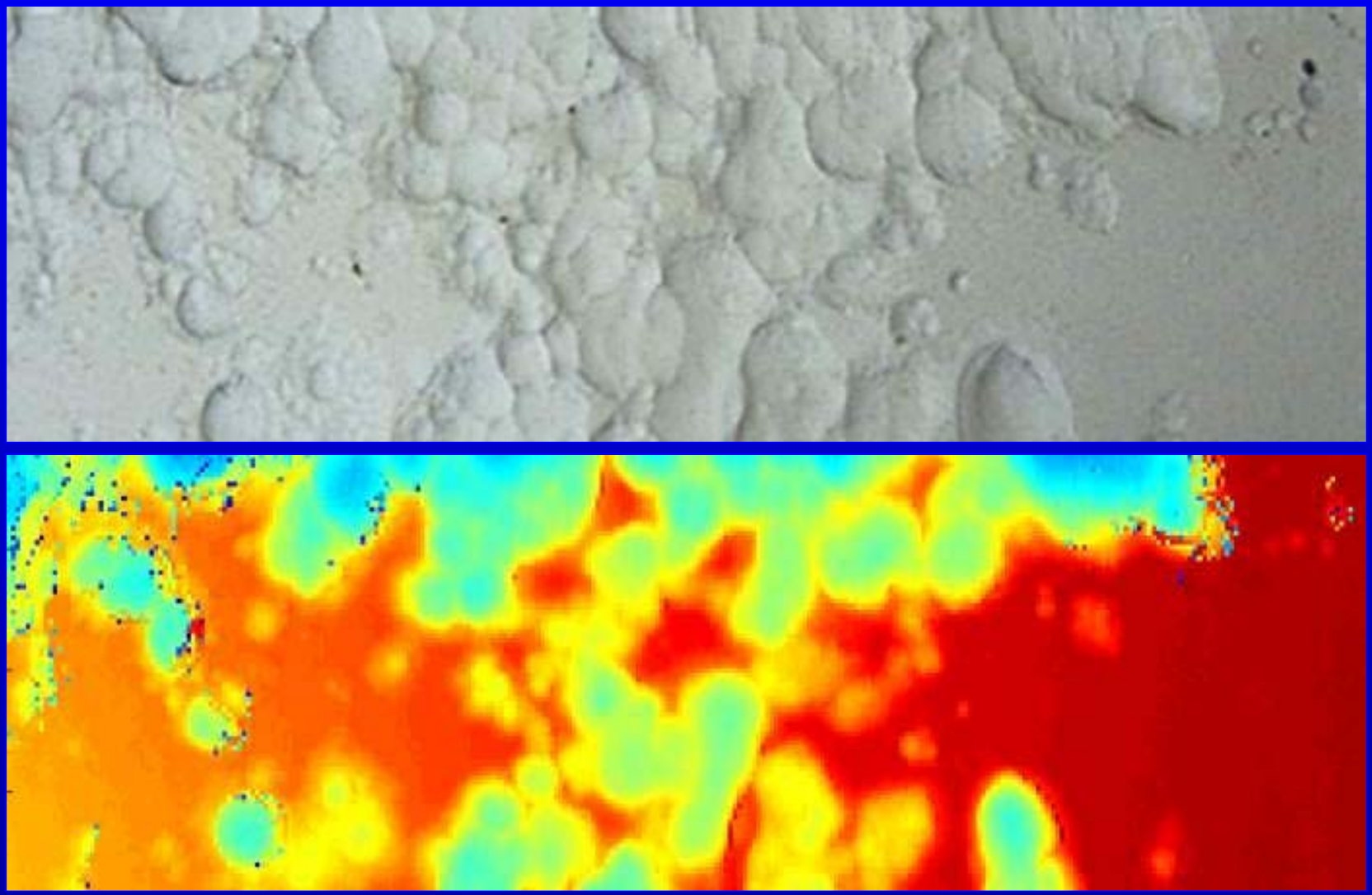
RTD Laser Scanner

Photo courtesy of RTD Quality Services

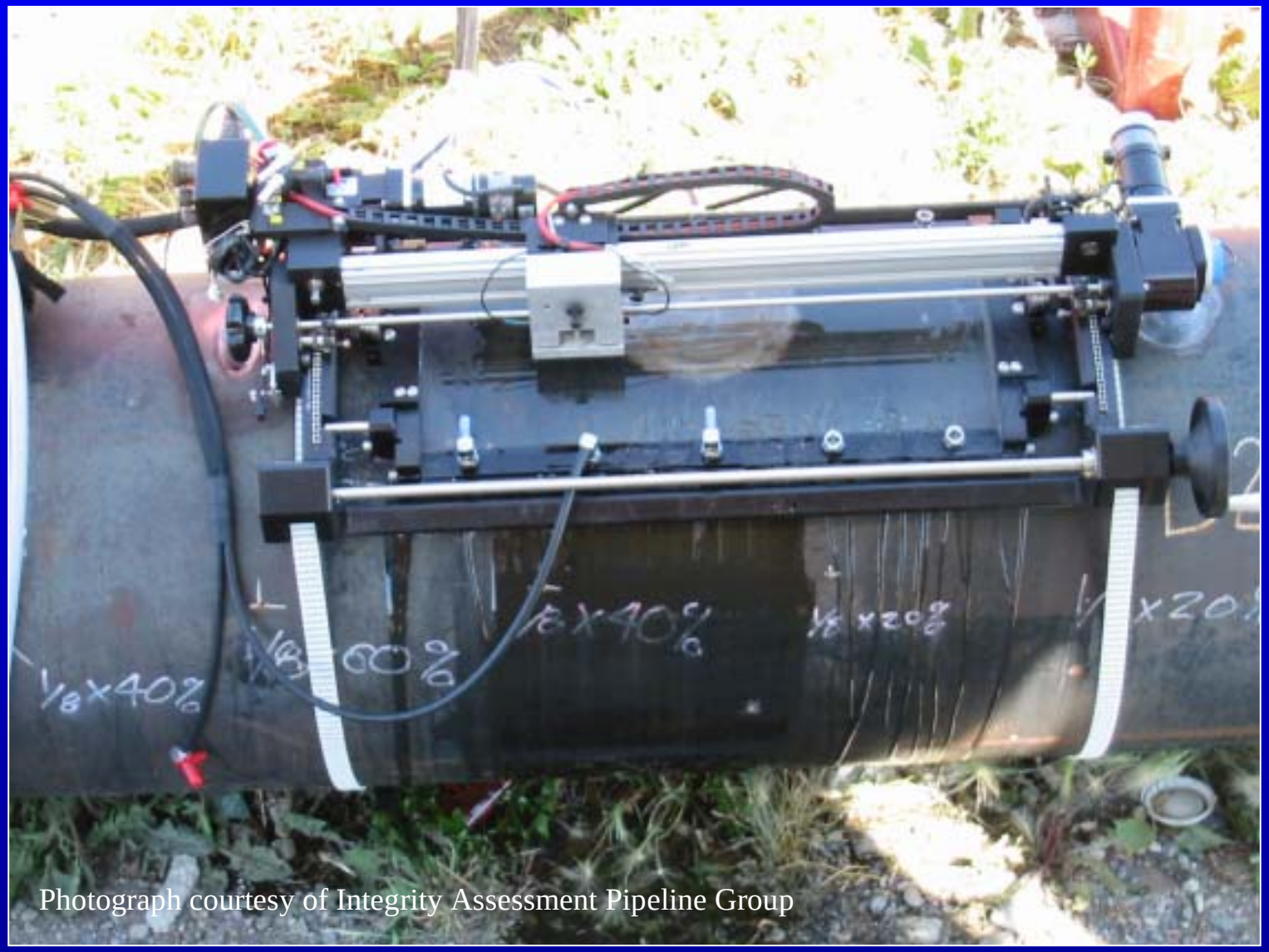
Characteristics of Laser Scanner

- High spatial and depth resolution
- Accuracy generally independent of corrosion depth or diameter
- Requires clean surface free of dirt, scale and residual coating material
- Relatively complex deployment, environmentally sensitive

Laboratory Laser Scan

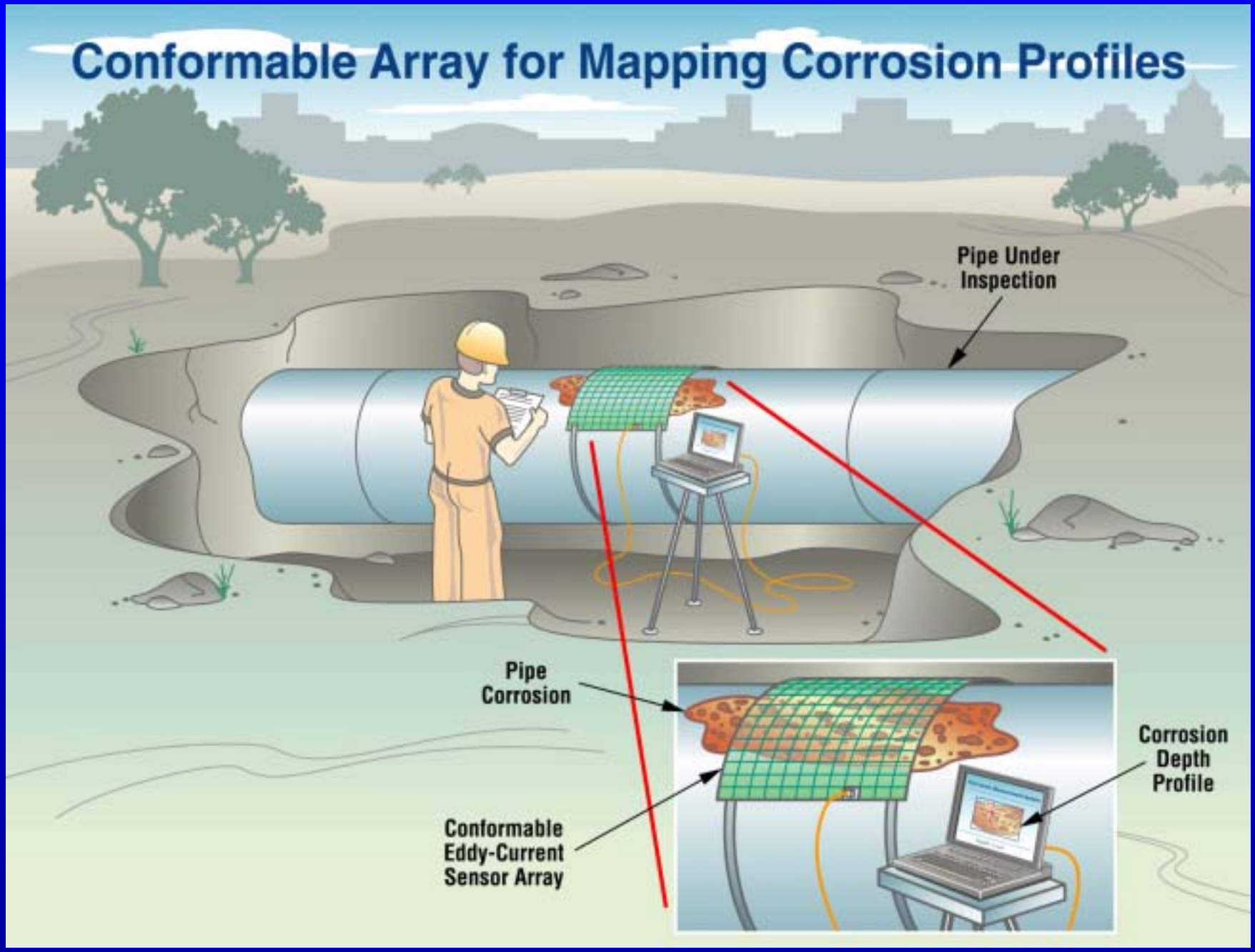


Advanced Digital Ultrasonic Mapper



Photograph courtesy of Integrity Assessment Pipeline Group

Conformable Array for Mapping Corrosion Profiles



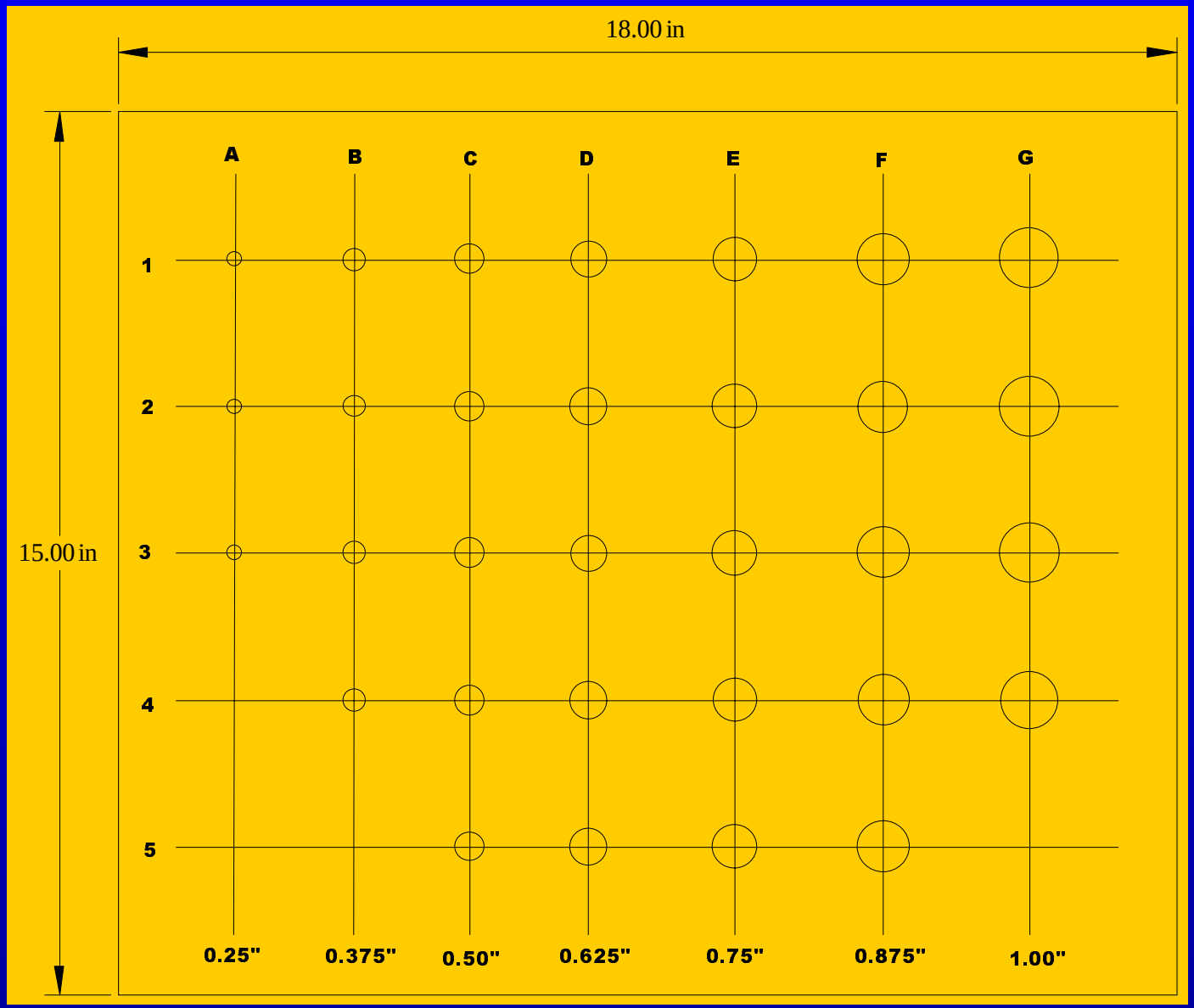
Major Unknowns

- What is smallest diameter pit that can be measured?
- What is the deepest pit that can be measured?
- What is the accuracy of depth measurement?
- What sensor density will be required to properly measure small pits?

Eddy Current Basis of Array Operation

- Alternating current excitation generates reaction currents in workpiece
- Coil impedance is affected by electrical conductivity, magnetic permeability and geometry
- Phase and amplitude of reaction currents, and thus transformer coupling, are affected by distance to workpiece

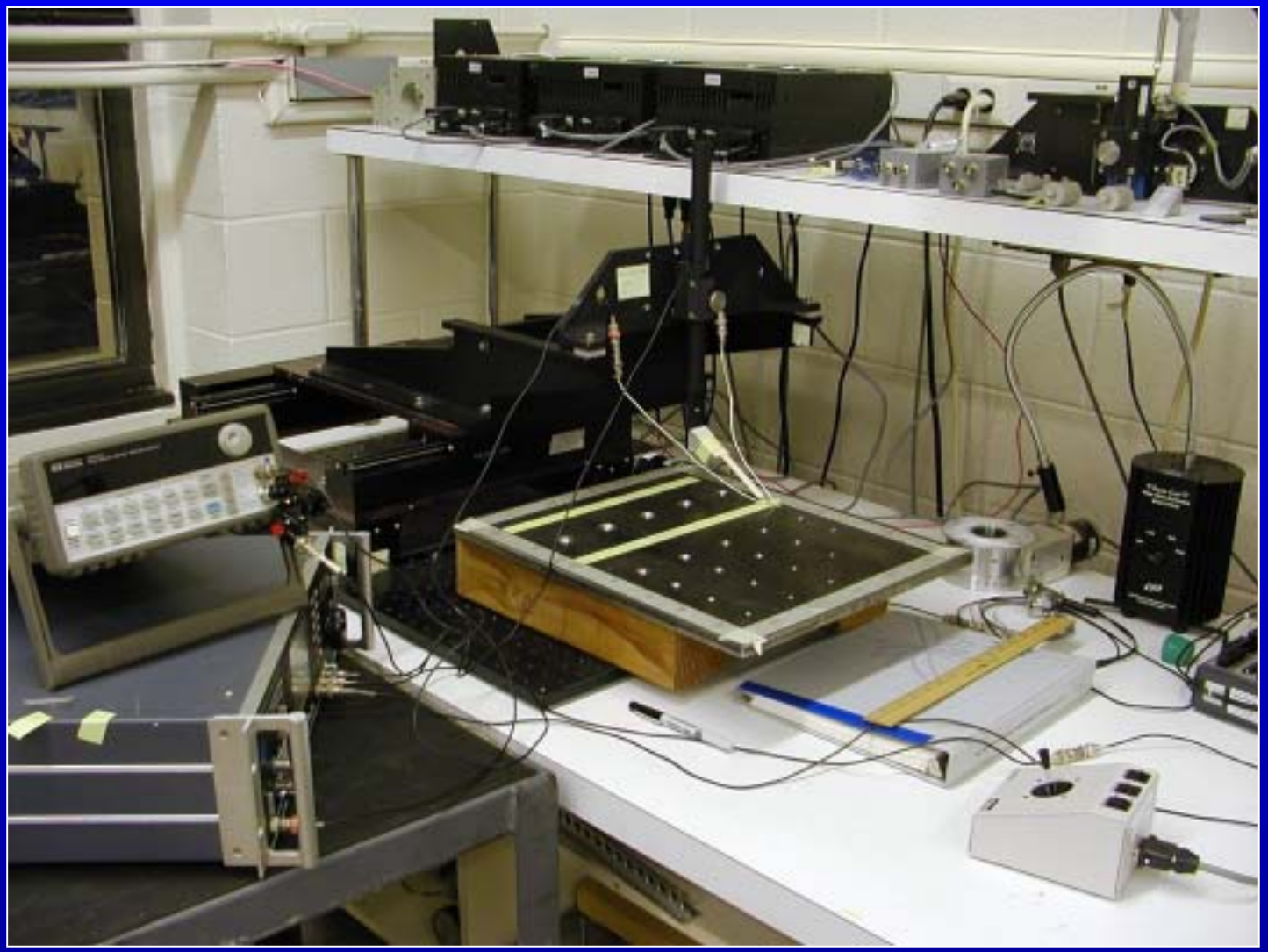
Pit Test Plate



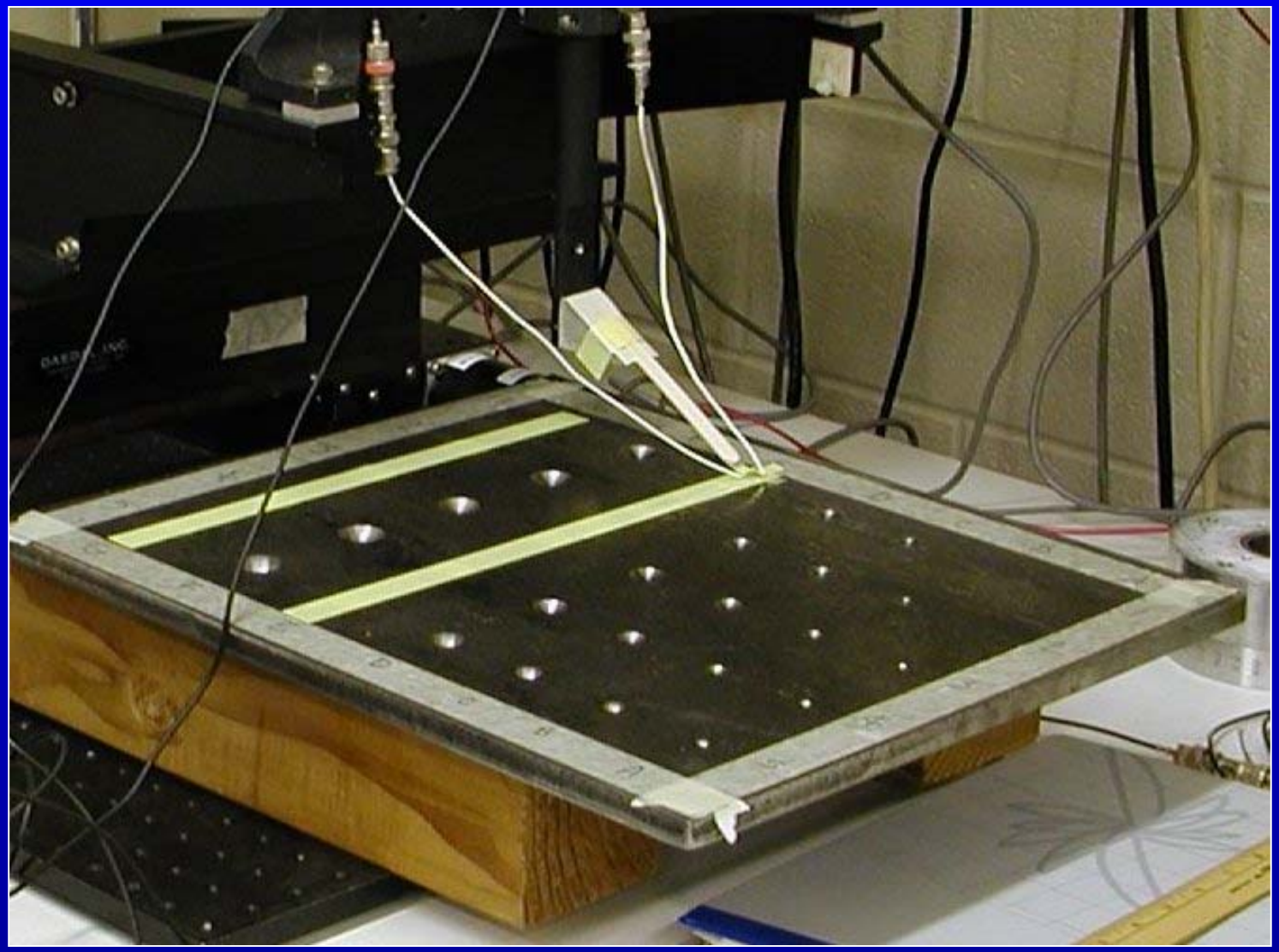
Pit Test Plate

Column	No. of pits	Diameter (in.)	Min. Depth (in.)	Max. Depth (in.)
A	3	0.250	0.048	0.125
B	4	0.375	0.042	0.188
C	5	0.500	0.043	0.250
D	5	0.625	0.068	0.313
E	5	0.750	0.100	0.375
F	5	0.875	0.141	0.438
G	4	1.000	0.191	0.480

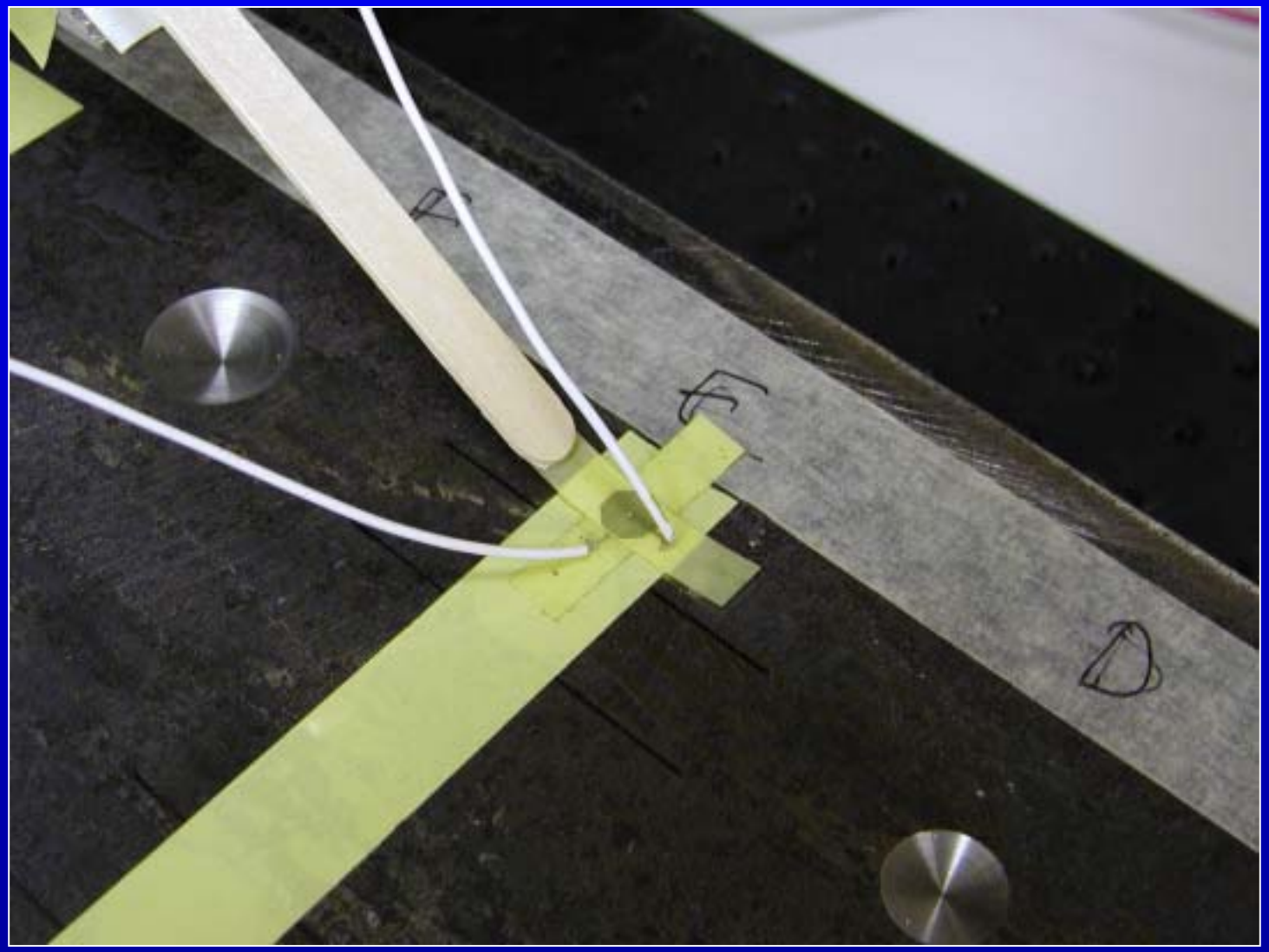
Laboratory Setup



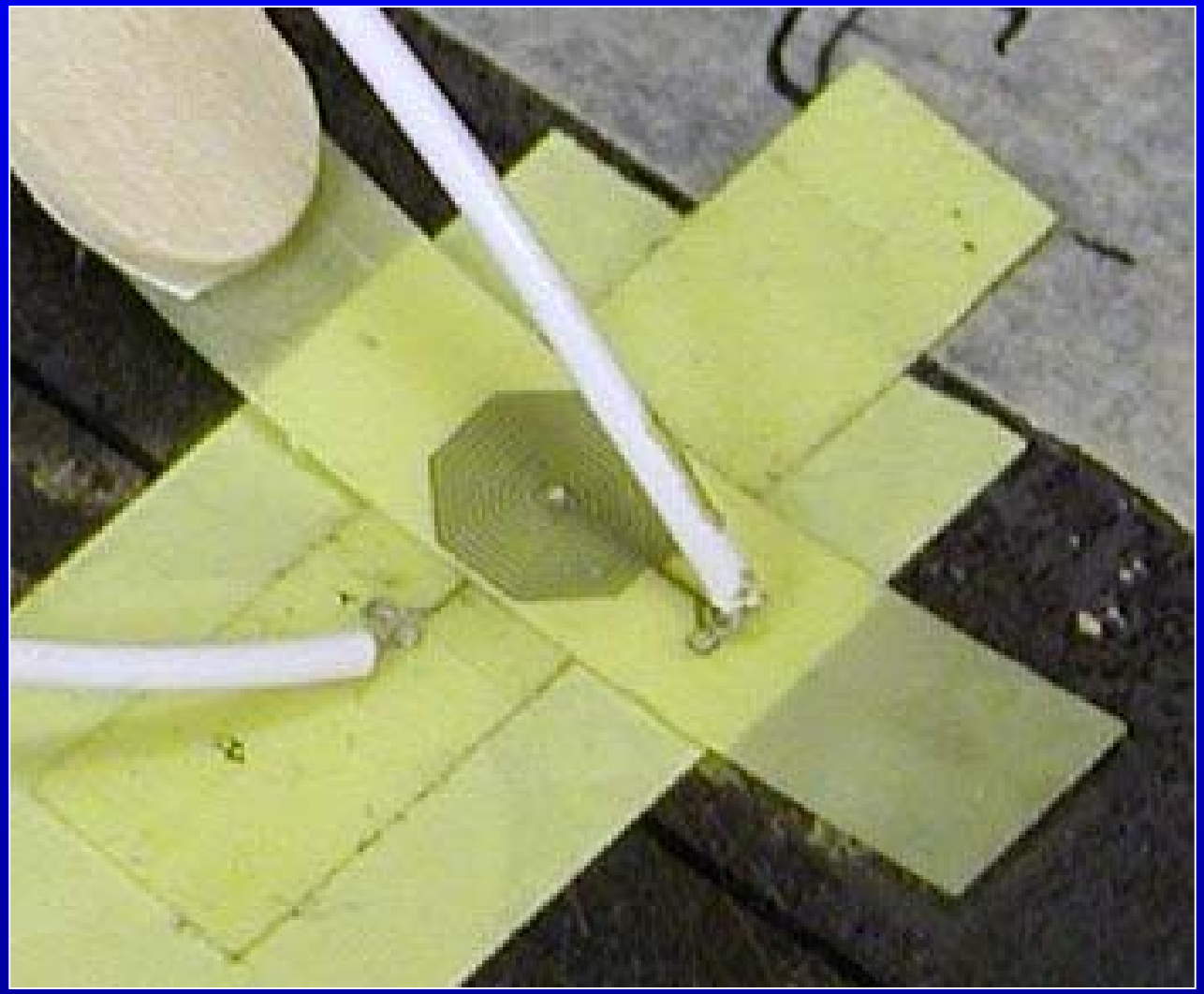
Pit Test Plate



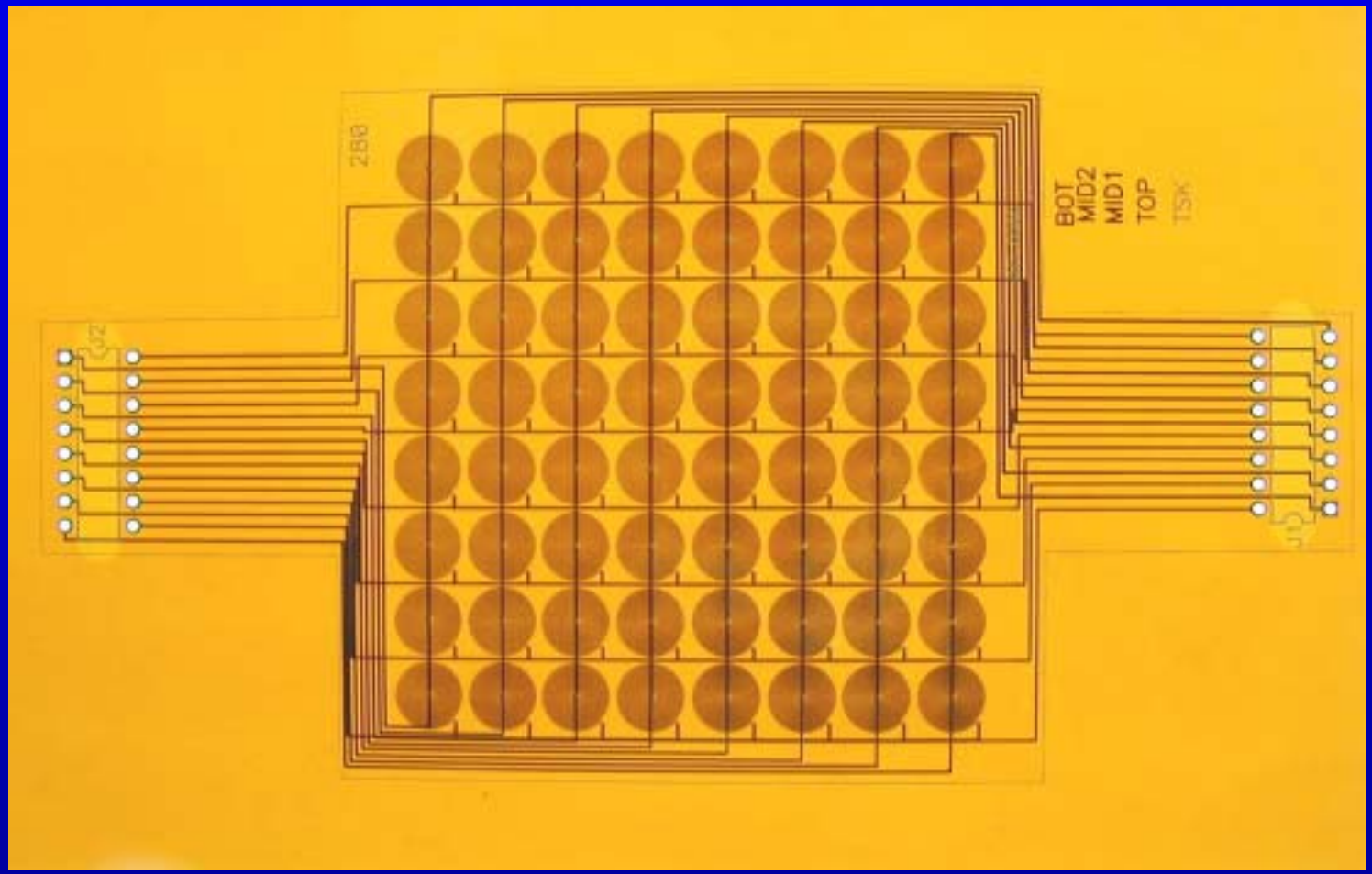
Dual Probe Pair



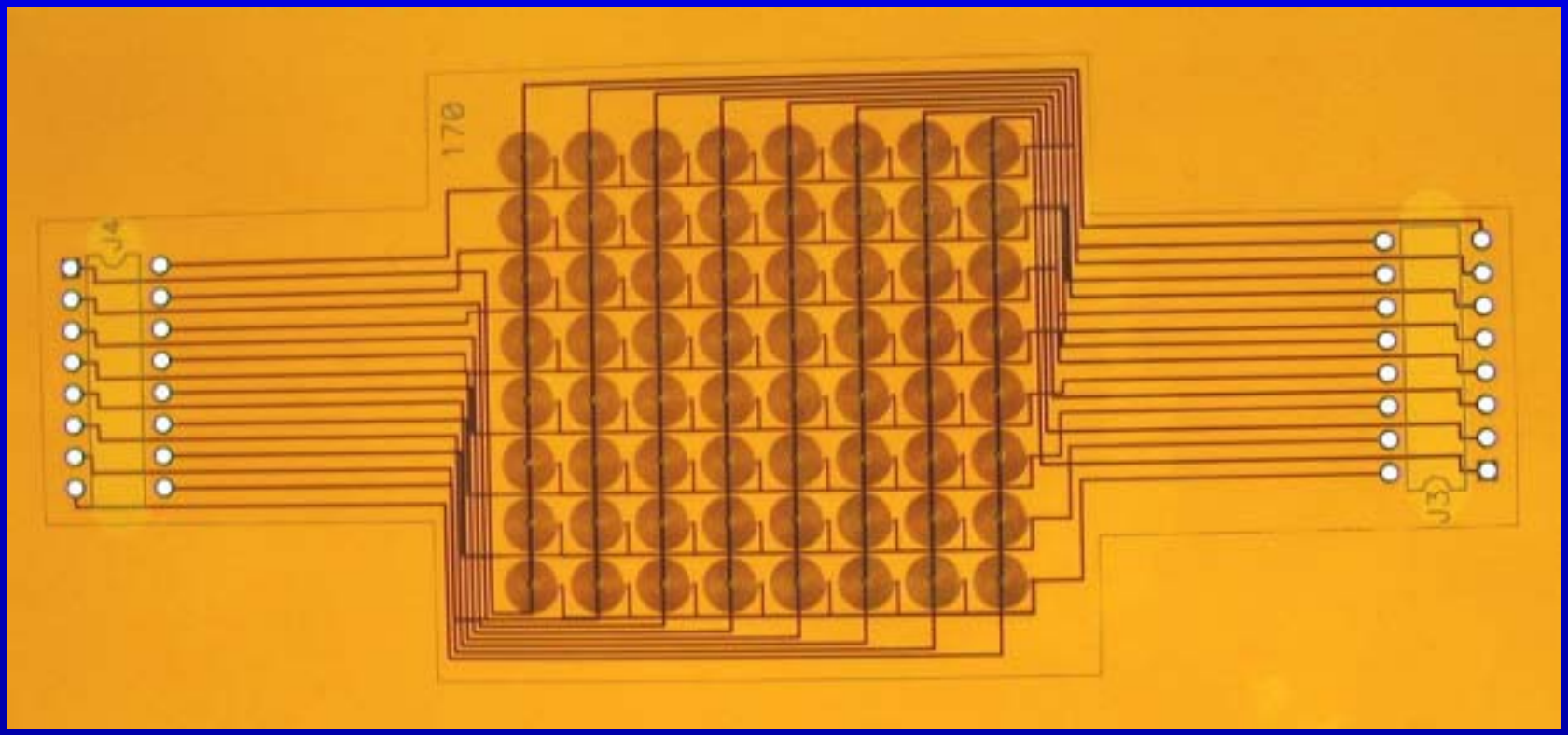
Coil Pair



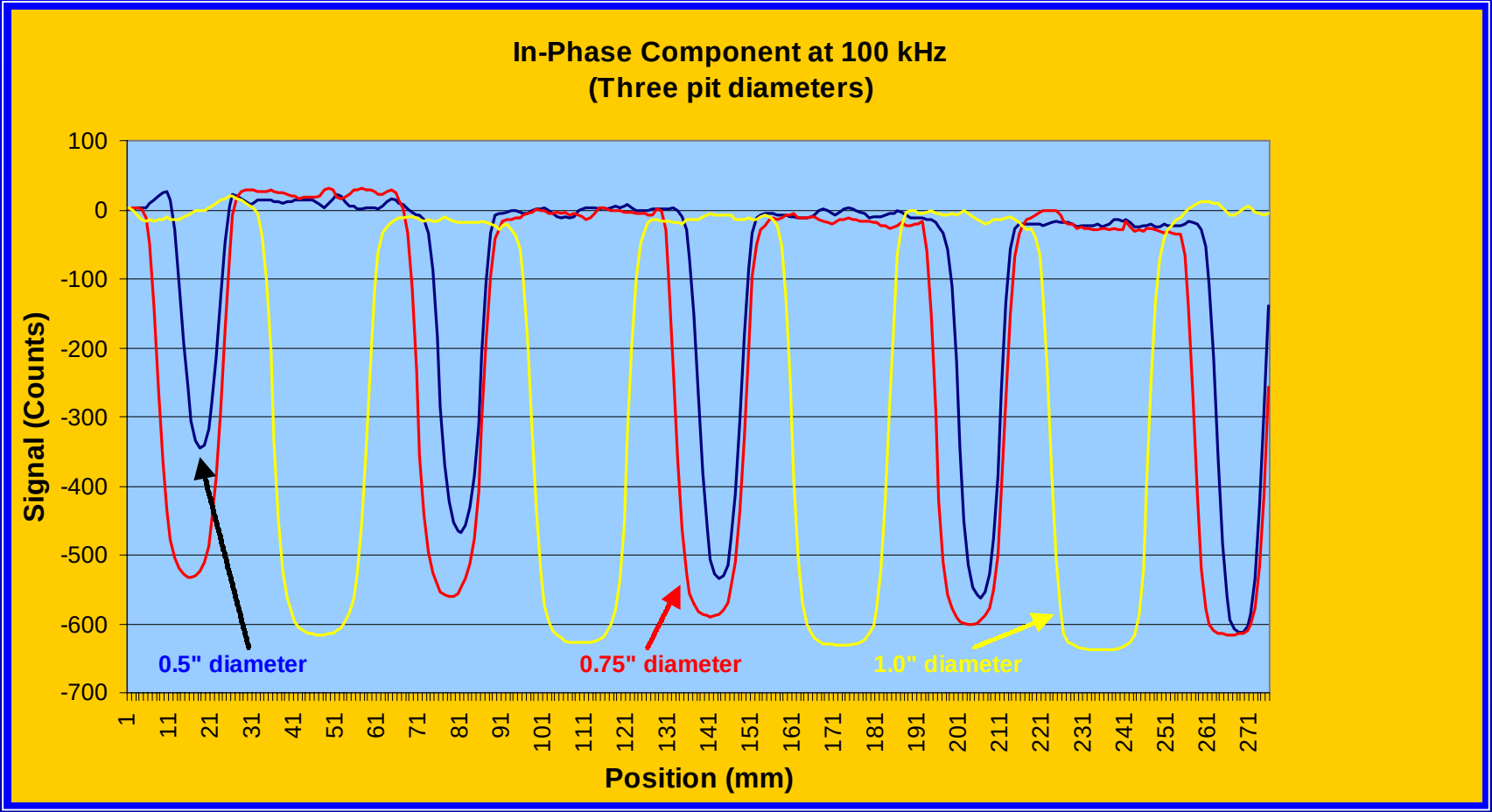
Large Array Board



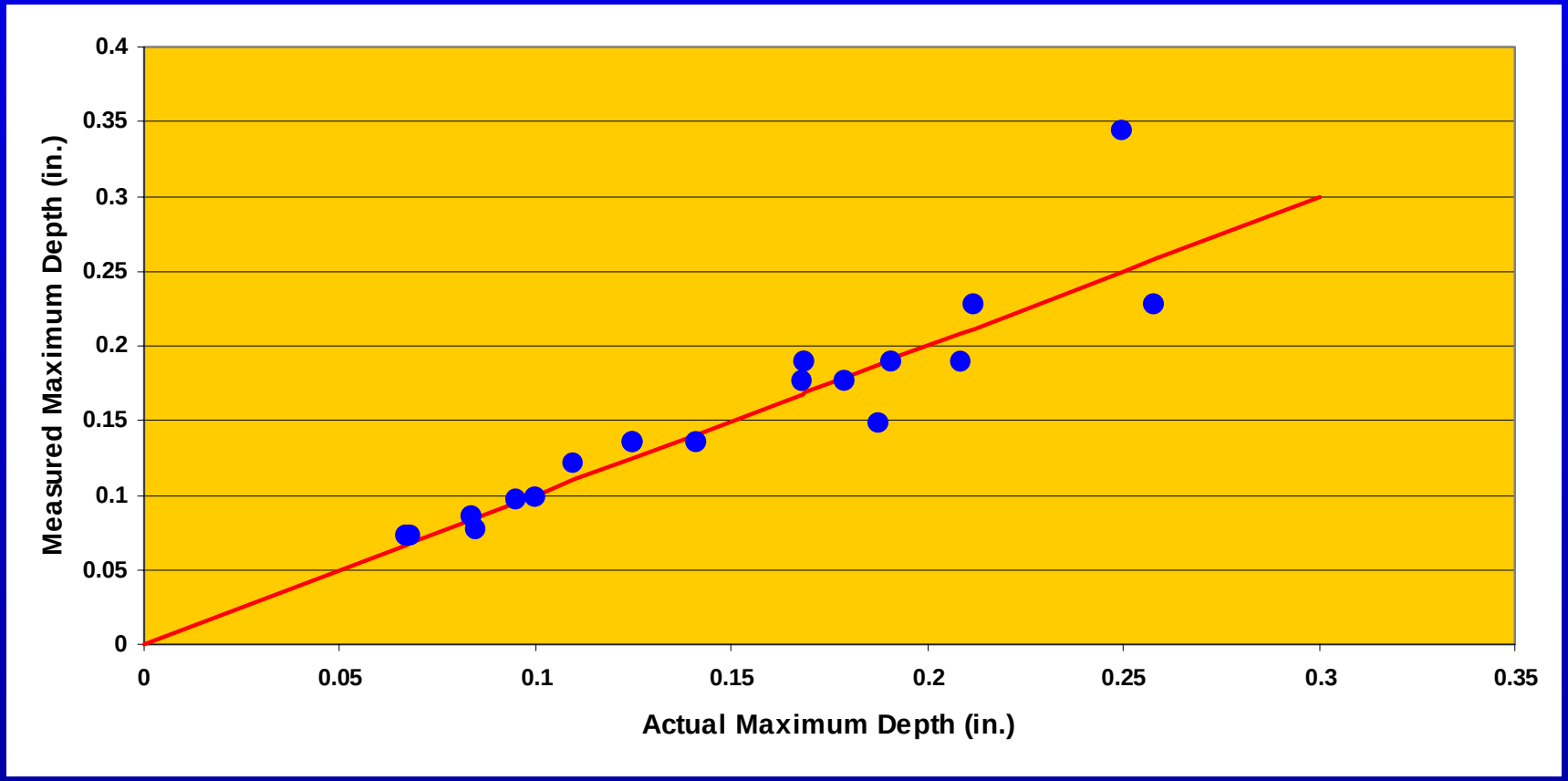
Small Array Board



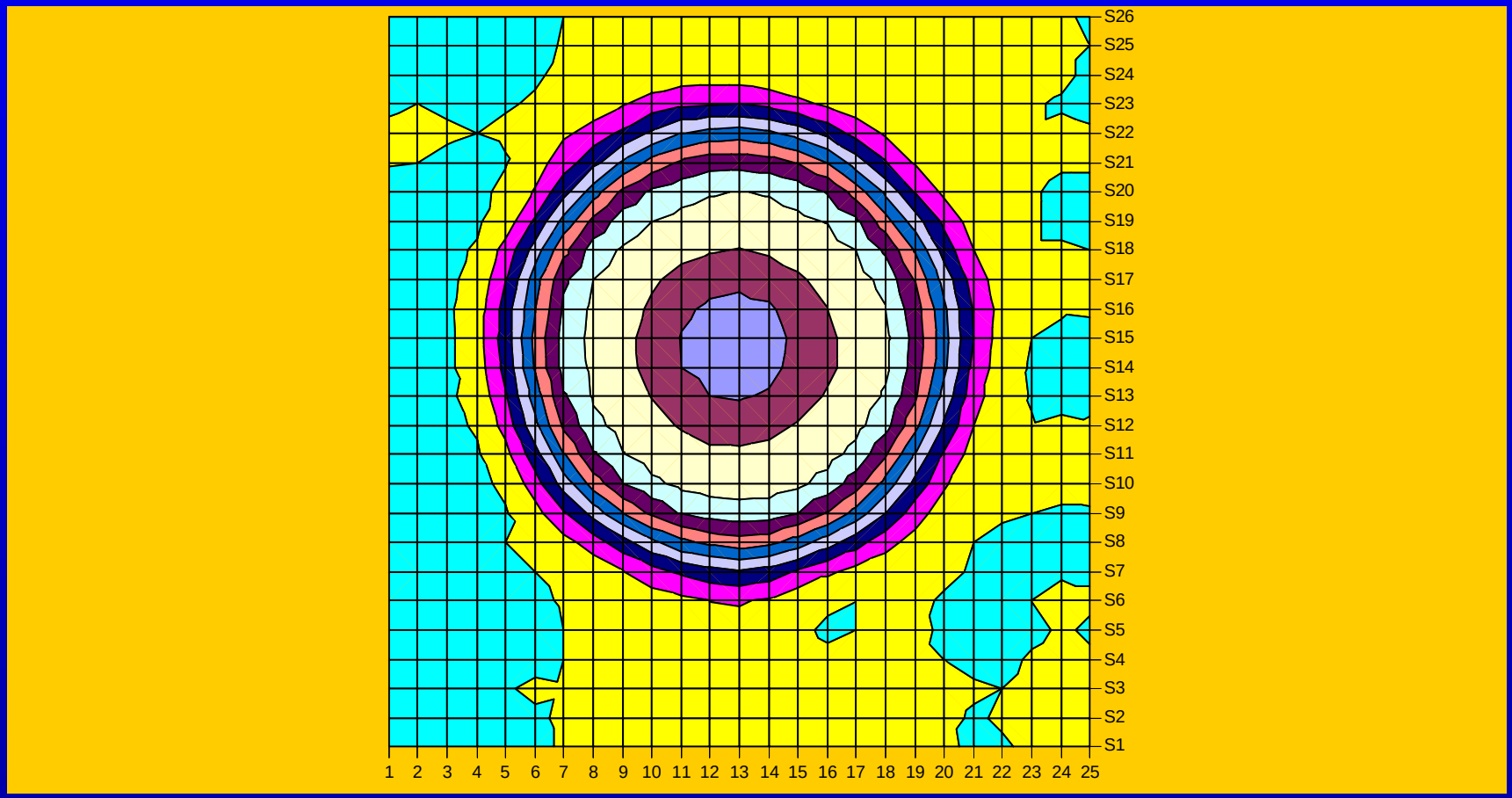
Center Scan of 14 Pits



Pit Depth Measurement Accuracy (Large Coil)

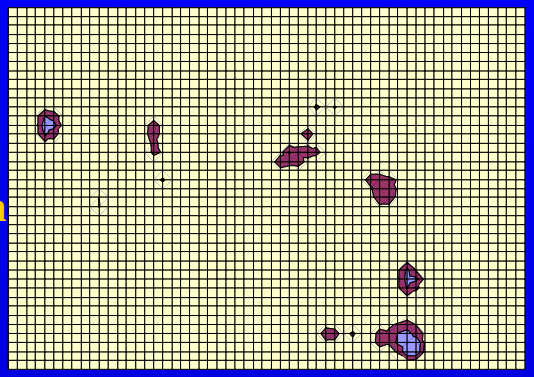


Color Map of 0.5 inch Pit (1 mm resolution)

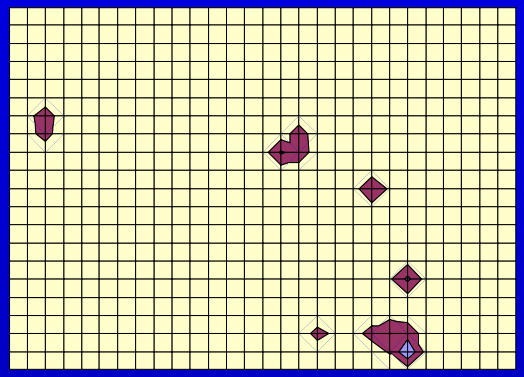


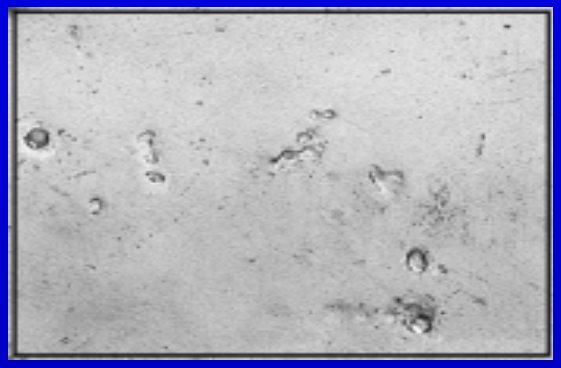
Effects of Array Density (Pitting Corrosion)

2 mm

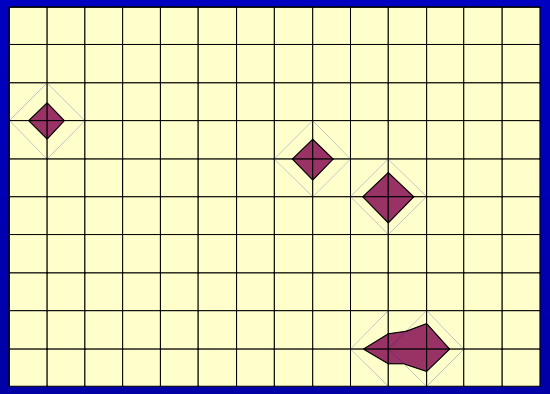


4 mm

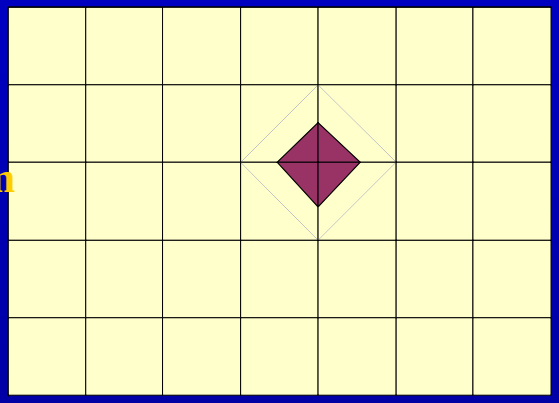




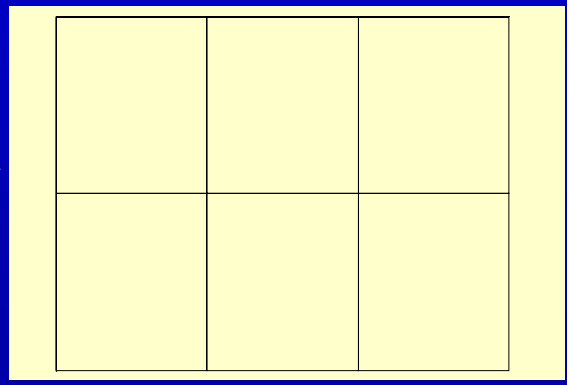
8 mm



16 mm

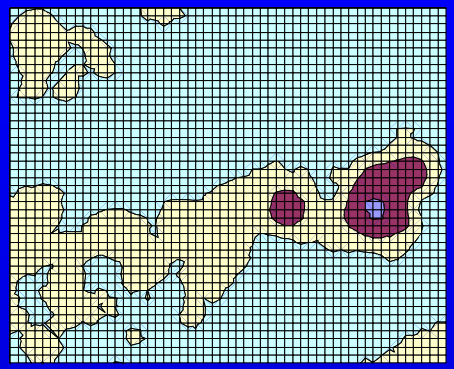


32 mm

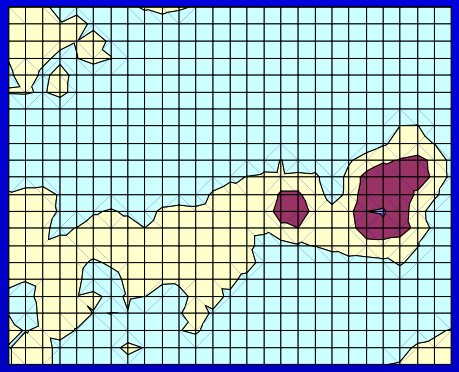


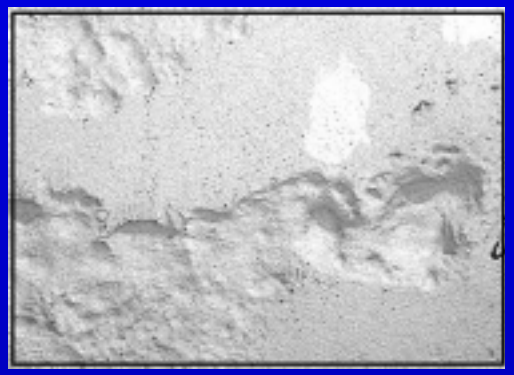
Effects of Array Density
General Corrosion

2 mm

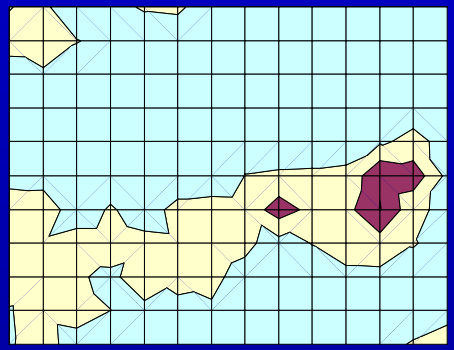


4 mm

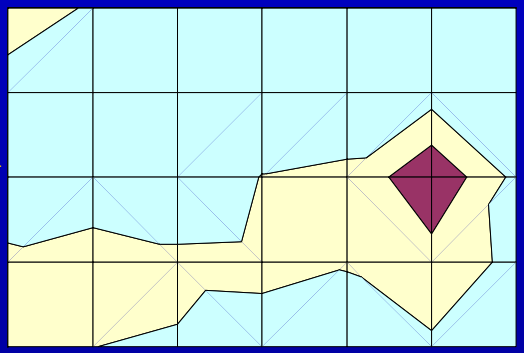




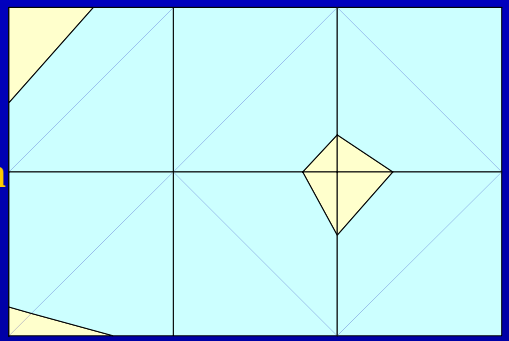
8 mm



16 mm

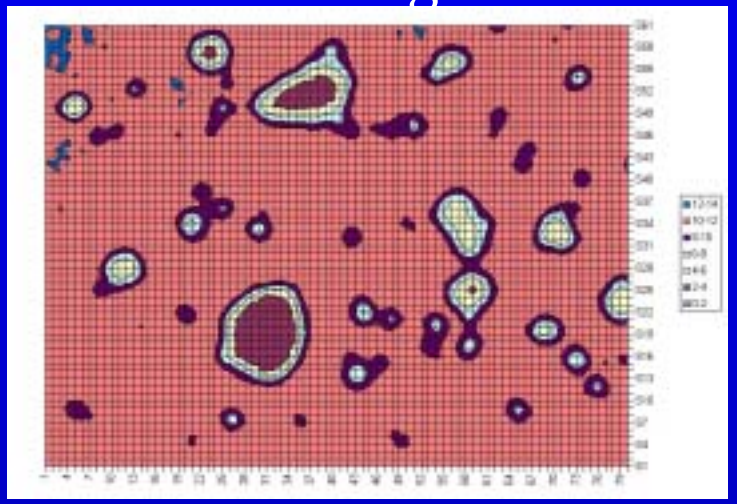


32 mm

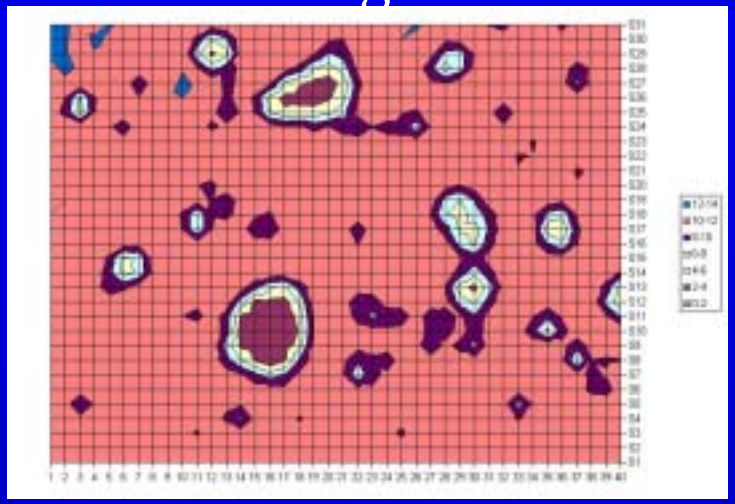


Effect of Reducing Grid Size

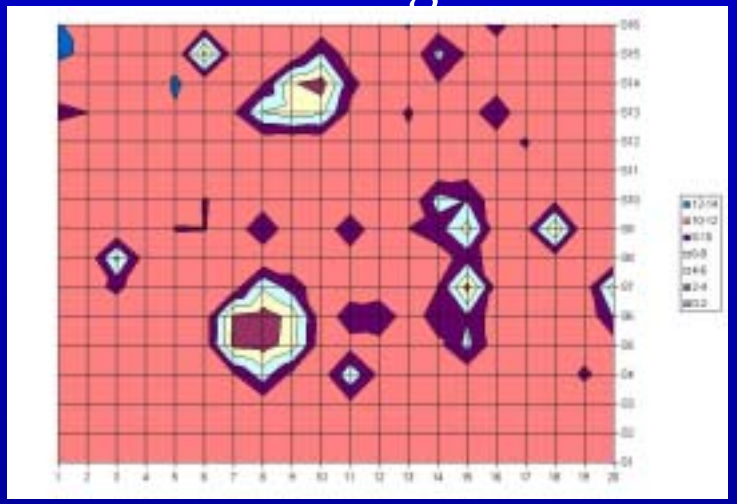
0.050” grid



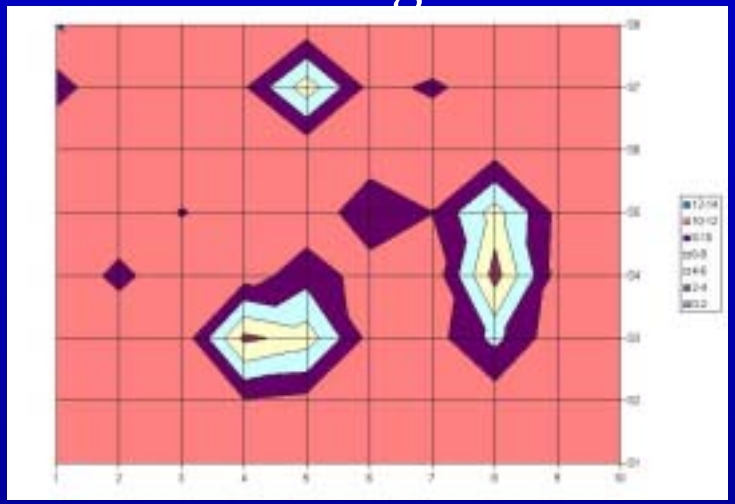
0.100” grid



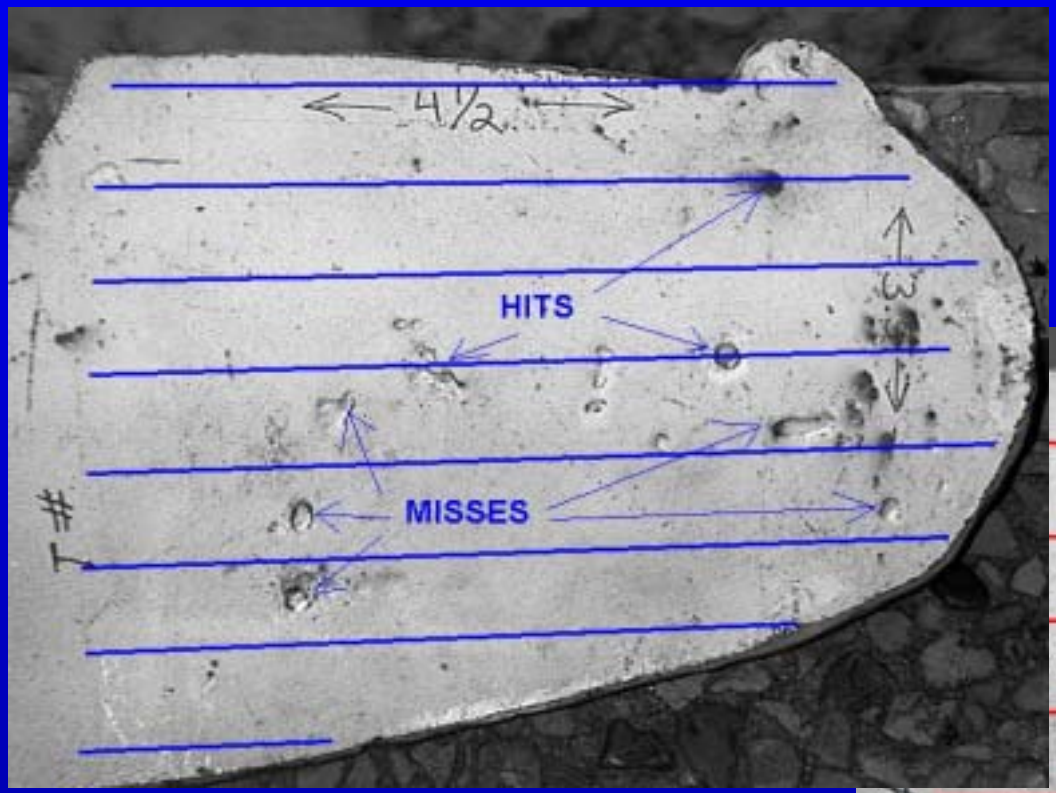
0.200” grid



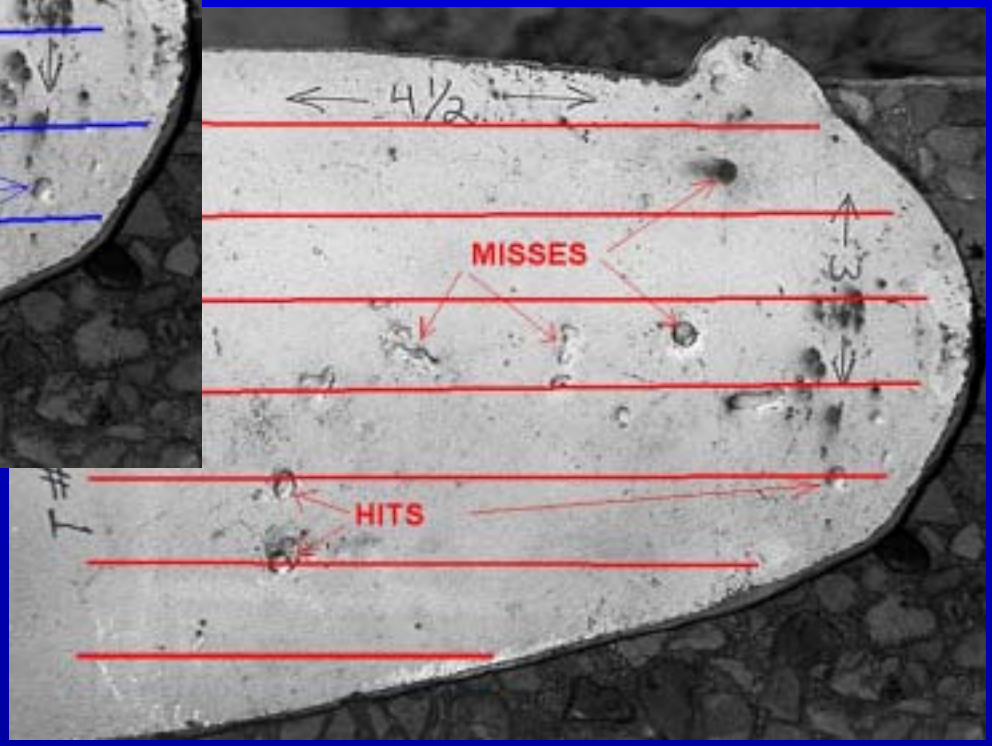
0.400” grid



Effect of Array Position on Measurement of Small Pits



Constant channel spacing with variable phase.



Can be critical for isolated pitting

Conclusions to Date

- Flexible eddy current coil can be used to measure pit depths in steel.
- Measurement is relatively independent of pit diameter as long as the pit is larger than sensing coil
- Improvement is needed for measurement of deeper pits (>0.250”)